

NAME \_\_\_\_\_

ID # \_\_\_\_\_

## HONORS ELEMENTARY ORGANIC CHEMISTRY I (2331H)

9:05 – 9:55 am, October 23, 2013

### Exam 2

If you want to pick this exam up on Friday in class (in public), please check the box on the right:

If you do not check the box, I will not bring your exam to class on Friday, and you will need to pick up your exam in private from Chemistry department staff in 115 Smith beginning Monday, October 28<sup>th</sup>. Exams that are not picked up within two weeks will be disposed of.

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A periodic table is attached to the back of this exam as an aid. Otherwise, you are not permitted to use any other materials (including notes, books, or electronic devices of any kind).

Right now, write your name and student ID number at the top of this page. When the exam begins, please write your name at the top of the next page.

You may use pen or pencil. However, re-grades will be considered only for exams completed in pen.

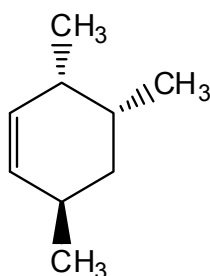
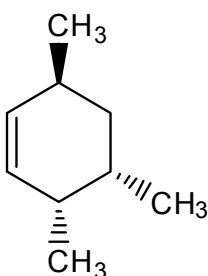
Please write your answers in the boxes/spaces provided. If your answer is not in the appropriate space (say, for example, it's on the back of the page), draw us an arrow and/or note telling us where to look.

NAME \_\_\_\_\_

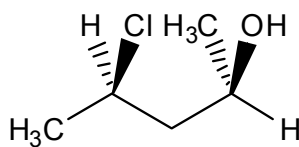
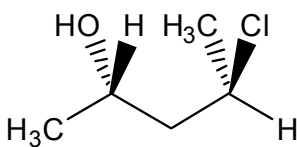
Scoring: 1. \_\_\_\_\_ / 12                      4. \_\_\_\_\_ / 15  
2. \_\_\_\_\_ / 16                      5. \_\_\_\_\_ / 23  
3. \_\_\_\_\_ / 15                      6. \_\_\_\_\_ / 19

**Total Score:** \_\_\_\_\_ / 100

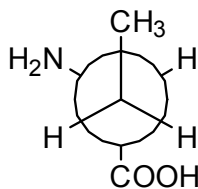
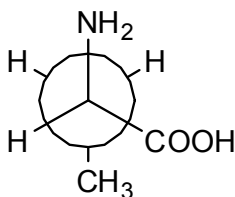
1. (12 pts) How would you describe the relationship between each of the pairs of structures below? Are they enantiomers or diastereomers, or are they just two ways of illustrating the same molecule? **Circle one answer** for each pair.



**ENANTIOMERS**  
*or*  
**DIASTEREOMERS**  
*or*  
**SAME MOLECULE**

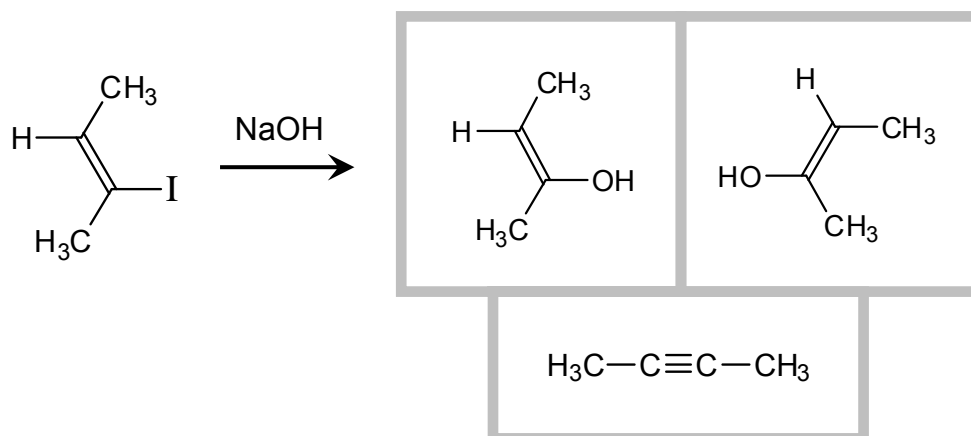
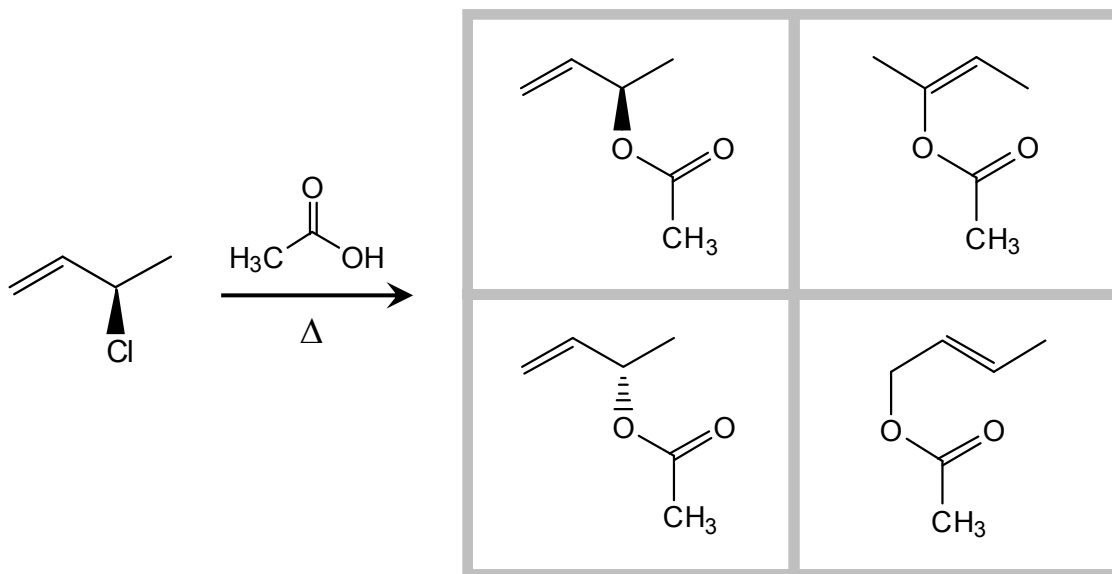
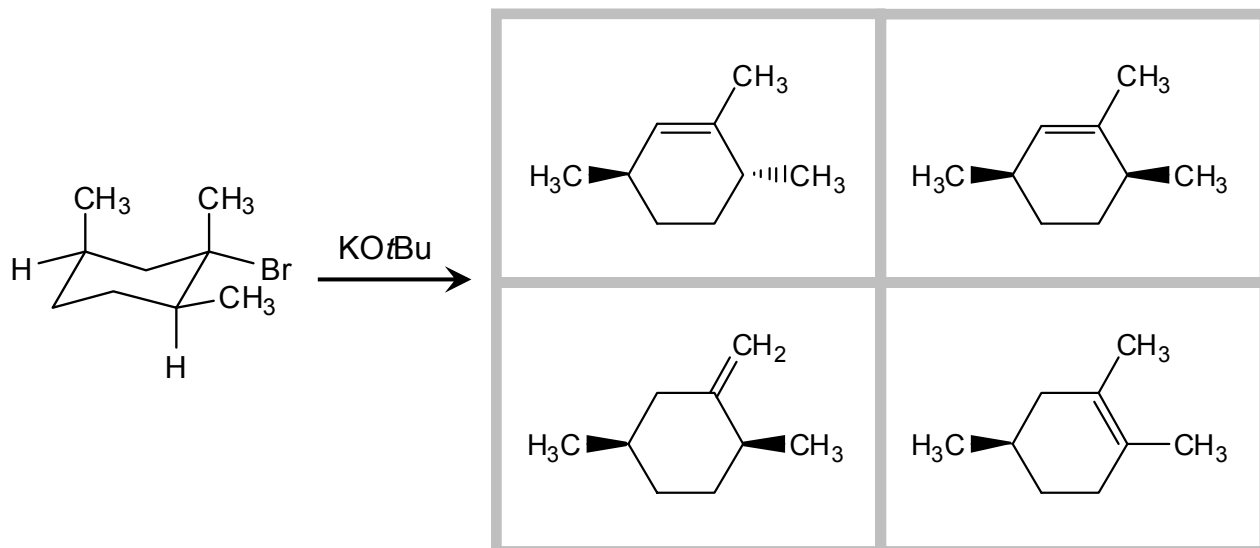


**ENANTIOMERS**  
*or*  
**DIASTEREOMERS**  
*or*  
**SAME MOLECULE**

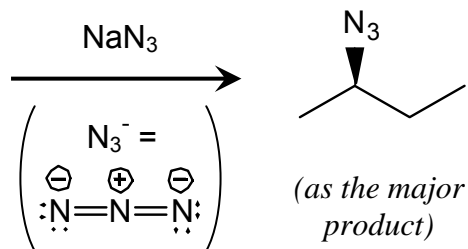
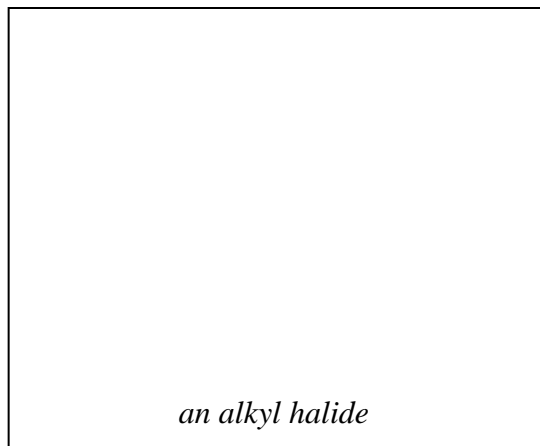
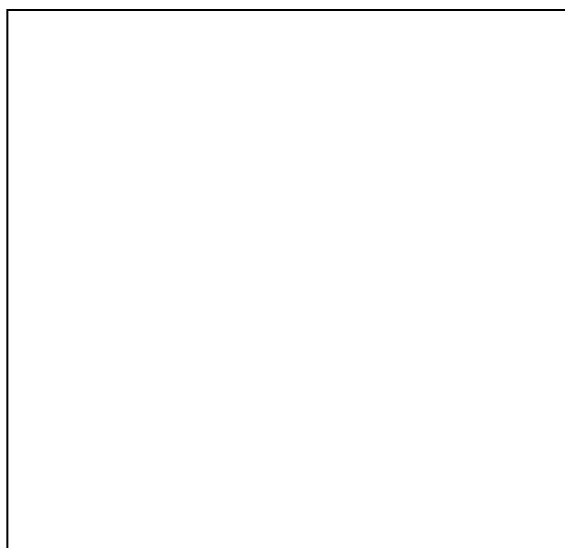
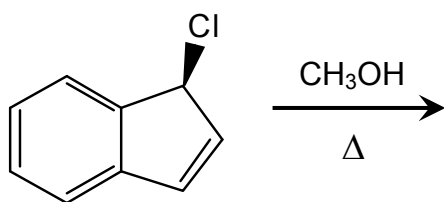
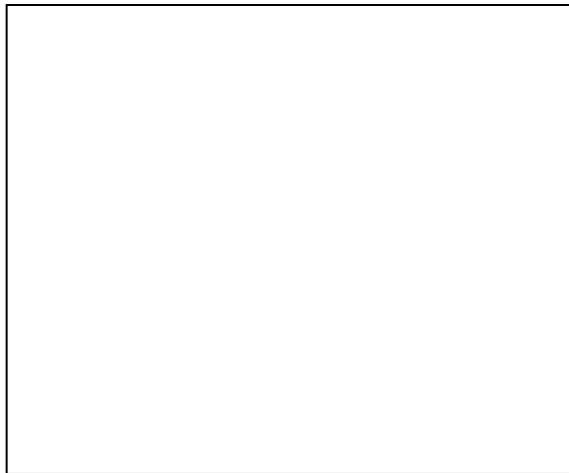
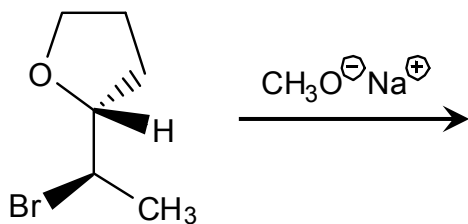


**ENANTIOMERS**  
*or*  
**DIASTEREOMERS**  
*or*  
**SAME MOLECULE**

2. (16 pts) For each reaction shown below, **circle all potential products**. Keep in mind that, for each case, you might circle one, multiple, or no molecules.



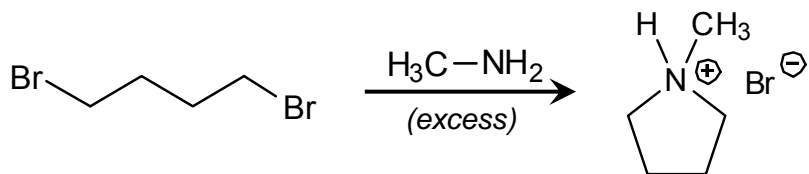
3. (15 pts) Draw the missing reactant or product in the empty boxes. For products, give the predominant, most favored product. Illustrate stereochemistry in your answer where appropriate. For reactions that yield multiple enantiomers, draw only one enantiomer in the box, and include the note “+ enantiomer”.



4. (15 pts) For the reaction shown below, draw a mechanism that explains how the product is generated from the starting material. In your answer, make sure that you:

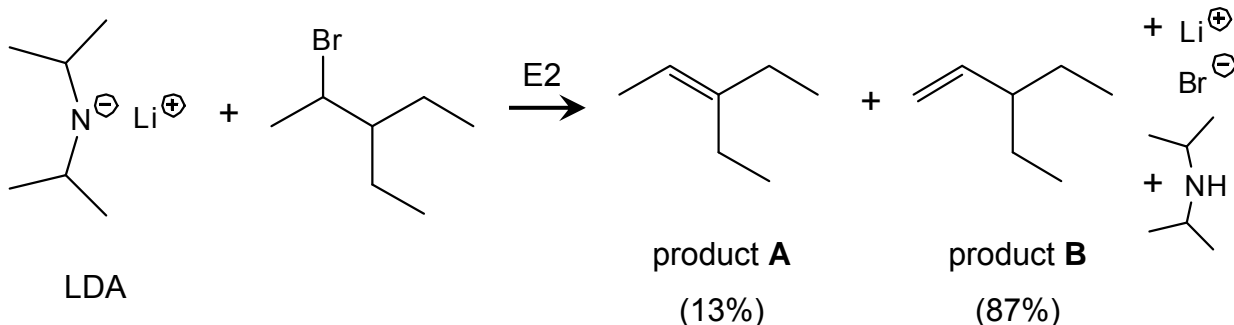
- Draw each step of the mechanism separately;
- Use “electron pushing” to show where the electrons in each step go;
- Use only the molecules that you are given; do not invoke reactants or solvents that aren't in the problem.

In this (and any) mechanism problem, “excess” means “use as many of these as you like”.

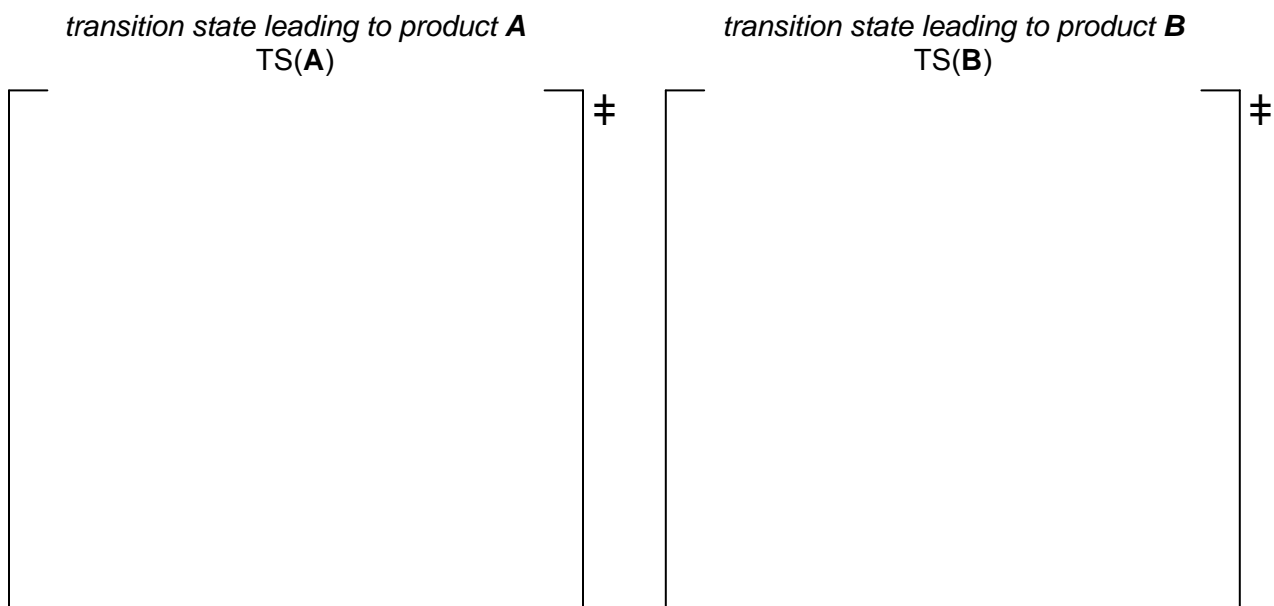


A large empty rectangular box provided for drawing the reaction mechanism.

5. (23 pts) Lithium diisopropylamide (LDA) is a strong, sterically hindered base that reacts with alkyl halides preferentially via E2 elimination. For example, LDA reacts with 2-bromo-3-ethyl-pentane to yield two alkenes:



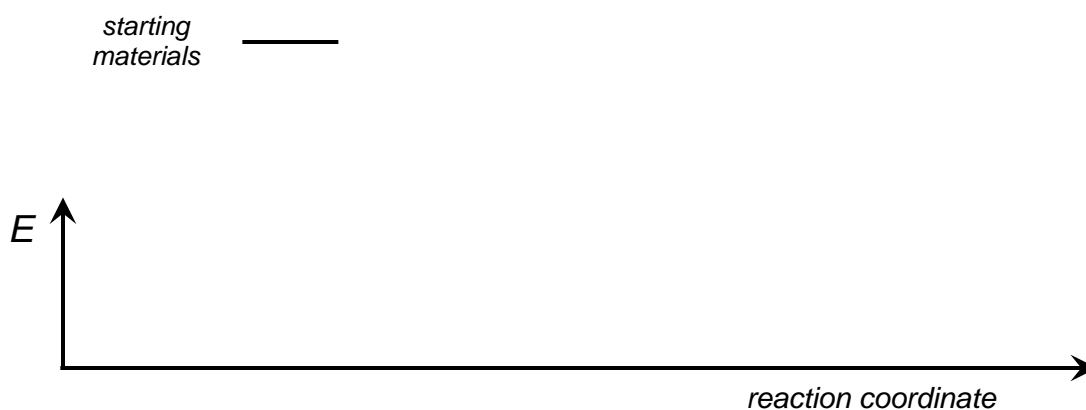
- (a) Which of the two alkenes is more substituted, **A** or **B** ? (Circle one.)
- (b) Which of the two products is more stable, **A** or **B** ? (Circle one.)
- (c) In the brackets below, draw the structure of the rate-determining transition state encountered on the path to each product.



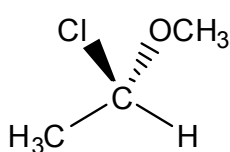
- (d) Which transition state is more stable, **TS(A)** or **TS(B)** ? (Circle one.)

(Problem 5 continues on the next page)

- (e) Draw a potential energy diagram that describes the generation of both products **A** and **B** from starting materials. Your diagram should have one curve leading to each product. Label transition-state ["TS(A)" and "TS(B)"] and product ("A" and "B") energy levels on your drawing. Your answer should also clearly illustrate the relative energies of transition states and products. I have already drawn the starting material energy for you.



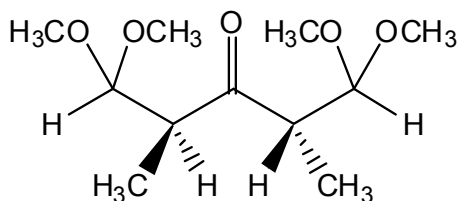
6. (19 pts) On the structures below, **label each chiral center** with its appropriate Cahn-Ingold-Prelog designation [(*R*) or (*S*)]. Make it clear which atom in the drawing you are labeling. Then, for each structure, **circle** whether you think the molecule is chiral or achiral.



**CHIRAL**

or

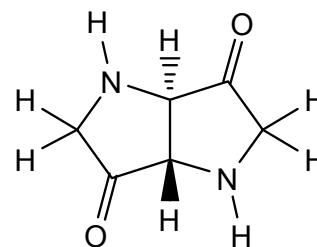
**ACHIRAL** ?



**CHIRAL**

or

**ACHIRAL** ?



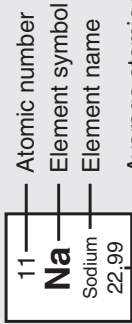
**CHIRAL**

or

**ACHIRAL** ?

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1	1	<b>H</b> Hydrogen 1.01	2	<b>He</b> Helium 4.00	3	4	<b>Li</b> Lithium 6.94	5	<b>Be</b> Beryllium 9.01	6	7	<b>B</b> Boron 10.81	8	<b>C</b> Carbon 12.01	9	<b>N</b> Nitrogen 14.01	10	<b>O</b> Oxygen 16.00	11	<b>F</b> Fluorine 19.00	12	<b>Ne</b> Neon 20.18	13	<b>Na</b> Sodium 22.99	14	<b>Mg</b> Magnesium 24.31	15	<b>Al</b> Aluminum 26.98	16	<b>Si</b> Silicon 28.09	17	<b>P</b> Phosphorus 30.97	18	<b>S</b> Sulfur 32.07	19	<b>Cl</b> Chlorine 35.45	20	<b>Ar</b> Argon 39.95	21	<b>K</b> Potassium 39.10	22	<b>Ca</b> Calcium 40.08	23	<b>Sc</b> Scandium 44.96	24	<b>Ti</b> Titanium 47.87	25	<b>V</b> Vanadium 50.94	26	<b>Cr</b> Chromium 52.00	27	<b>Mn</b> Manganese 54.94	28	<b>Fe</b> Iron 55.85	29	<b>Ni</b> Nickel 58.69	30	<b>Cu</b> Copper 63.55	31	<b>Zn</b> Zinc 65.39	32	<b>Ga</b> Gallium 69.72	33	<b>Ge</b> Germanium 72.61	34	<b>As</b> Arsenic 74.92	35	<b>Se</b> Selenium 78.96	36	<b>Kr</b> Krypton 83.80	37	<b>Rb</b> Rubidium 85.47	38	<b>Sr</b> Strontium 87.62	39	<b>Y</b> Yttrium 88.91	40	<b>Zr</b> Zirconium 91.22	41	<b>Nb</b> Niobium 92.91	42	<b>Mo</b> Molybdenum 95.94	43	<b>Tc</b> Technetium (98)	44	<b>Ru</b> Ruthenium 101.07	45	<b>Rh</b> Rhodium 102.91	46	<b>Pd</b> Palladium 106.42	47	<b>Ag</b> Silver 107.87	48	<b>Cd</b> Cadmium 112.41	49	<b>In</b> Indium 114.82	50	<b>Sn</b> Tin 118.71	51	<b>Sb</b> Antimony 121.76	52	<b>Te</b> Tellurium 127.60	53	<b>I</b> Iodine 126.90	54	<b>Xe</b> Xenon 131.29	55	<b>Cs</b> Cesium 132.91	56	<b>Ba</b> Barium 137.33	57	<b>La</b> Lanthanum 138.91	58	<b>Ce</b> Cerium 140.12	59	<b>Pr</b> Praseodymium 140.91	60	<b>Nd</b> Neodymium 144.24	61	<b>Pm</b> Promethium (145)	62	<b>Sm</b> Samarium 150.36	63	<b>Eu</b> Europium 151.96	64	<b>Gd</b> Gadolinium 157.25	65	<b>Tb</b> Terbium 158.93	66	<b>Dy</b> Dysprosium 162.50	67	<b>Ho</b> Holmium 164.93	68	<b>Er</b> Erbium 167.26	69	<b>Tm</b> Thulium 168.93	70	<b>Yb</b> Ytterbium 173.04	71	<b>Lu</b> Lutetium 174.97	72	<b>Fr</b> Francium (223)	73	<b>Ra</b> Radium (226)	74	<b>Ac</b> Actinium (227)	75	<b>Rf</b> Rutherfordium (261)	76	<b>Hf</b> Hafnium 178.49	77	<b>Ta</b> Tantalum 180.95	78	<b>W</b> Tungsten 183.84	79	<b>Re</b> Rhenium 186.21	80	<b>Os</b> Osmium 190.23	81	<b>Ir</b> Iridium 192.22	82	<b>Pt</b> Platinum 195.08	83	<b>Au</b> Gold 196.97	84	<b>Hg</b> Mercury 200.59	85	<b>Tl</b> Thallium 204.38	86	<b>Pb</b> Lead 207.2	87	<b>Bi</b> Bismuth 208.98	88	<b>Po</b> Polonium (209)	89	<b>At</b> Astatine (210)	90	<b>Rn</b> Radon (222)	91	<b>Th</b> Thorium 232.04	92	<b>Pa</b> Protactinium 231.04	93	<b>U</b> Uranium 238.03	94	<b>Np</b> Neptunium (237)	95	<b>Pu</b> Plutonium (244)	96	<b>Am</b> Americium (243)	97	<b>Cm</b> Curium (247)	98	<b>Bk</b> Berkelium (247)	99	<b>Cf</b> Californium (251)	100	<b>Fm</b> Fermium (257)	101	<b>Md</b> Mendelevium (258)	102	<b>No</b> Nobelium (259)	103	<b>Lr</b> Lawrencium (262)	104	<b>Uu</b> Ununquadium (264)	105	<b>Uub</b> Ununbium (264)	106	<b>Uut</b> Ununtrium (266)	107	<b>Uuq</b> Ununquadium (266)	108	<b>Uuq</b> Ununquadium (268)	109	<b>Uuo</b> Ununoctium (268)

**Key**



Atomic number  
Element symbol  
Element name  
Average atomic mass\*

\* If this number is in parentheses, then it refers to the atomic mass of the most stable isotope.